CHAPTER 7
PROCESS COST ESTIMATES

CHAPTER CONTENTS

The costs of running a professional clothes cleaning business include rent, basic operating expenses, equipment, and labor. The equipment capacity, equipment type, and the location of the facility will affect the costs and economic viability of a professional cleaning operation. While some fabricare technologies have been in use for many years, others are still prototypes and have not yet been commercially marketed. As manufacturers gain expertise with new machines, and their production quantities increase, it is expected that there will be a decrease in the cost of production of new machines relative to established technologies and therefore a decrease in the cost of these options to fabricare operators (Pindyck and Rubinfeld, 1989).

This chapter focuses on the evaluation of a subset of costs associated with using fabricare technologies. Section 7.1 provides an introduction to the technologies and cost elements that have been included in the cost estimations that follow. Section 7.2 describes the methodology and assumptions used to estimate the cost components in this chapter. In Sections 7.3, 7.4, and 7.5, operational cost estimates are provided for the various fabricare process options. The analyses presented in this chapter should be regarded as a general guide for cost comparisons.

7.1 SUMMARY OF TECHNOLOGIES AND COST ELEMENTS MODELED

The technologies analyzed in this chapter include eight configurations of perchloroethylene (PCE) equipment, three configurations of hydrocarbon solvent (HC) equipment, and one configuration of machine wetcleaning technology.

The cost categories considered in this analysis are capital equipment cost, annualized cost of that equipment, annual solvent cost, energy cost, hazardous waste disposal cost, regulatory compliance costs, cost of filters and other supplies, and maintenance cost. These cost elements were chosen for evaluation because of their importance to facility operation, their potential for highlighting differences among technologies, and the availability of data. Exhibit 7-1 presents additional operating factors that are associated with fabricare operations, many of which are outside the scope of this analysis.

Exhibit 7-1. Potential Operating Factors Associated with Fabricare Facilities

Revenues
- Sale of product
- Marketing of by-product
- Change in process throughput
- Change in sales from improved corporate image and market share

Utilities
- Electricity
- Cooling and process water
- Refrigeration
- Fuel (gas or oil)
- Plant air and inert gas
- Sewerage

Direct Labor
- Operating labor and supervision
- Clerical labor
- Inspection (QA & QC)
- Worker productivity changes

Materials
- Direct product materials
- Solvents
- Wasted raw materials
- Transport and storage

Waste Management (Materials and Labor)
- Pre-treatment and on-site handling
- Storage, hauling, and disposal
- Insurance

Future Liability
- Fines and penalties
- Personal injury

Regulatory Compliance
- Equipment monitoring and lab fees
- Personal protective gear
- Reporting, notification, inspections, and manifesting
- Training (right-to-know, safety) and training materials
- Workplace signage and container labeling
- Penalties, fines, and solvent-use fees
- Insurance, closure and post-closure site maintenance

Indirect Labor
- Maintenance (materials and labor)
- Miscellaneous (housekeeping)
- Medical surveillance

Source: USEPA (1997).

Exhibit 7-2 provides a summary comparison of the various costs associated with a number of the fabricare technology options. This table is presented for illustrative purposes and provides comparisons among the technology types. Detailed explanations of how cost estimates were derived, as well as varying configurations of individual technologies, are provided in Sections 7.3, 7.4, and 7.5.

Wherever possible, the cost information reported is based on current prices of equipment and supplies offered by domestic manufacturers or distributors. If current prices are not available (e.g., equipment is no longer sold), then historic prices provided by a vendor are used if they are available. Costs or cost ranges may also be derived from secondary sources (materials published by the U.S. Environmental Protection Agency [USEPA], state and local governments, and industry). If prices are obtained from both current sources and published materials, the current prices are used, and the information from published sources is noted in the text. Where applicable, sample calculations are included for each cost element.

Exhibit 7-2. Summary of Estimated Process-Dependent Cost Components for Selected Fabricare Technologies[a]

Fabricare Technology[b]	Capital Cost of Base Equipment[c]	Capital Cost Total[d]	Annualized cost of Equipment[e]	Annual Cost Solvent[f]	Annual Energy Cost[g]	Regulatory Compliance Costs[h]	Annual Cost Hazardous Waste[i]
PCE	$38,511	$38,511	$4,228	$1,434	$136	$3,680	$4,594
HC	$37,432	$37,432	$4,110	$2,236	NA	NA	$9,820
Machine Wetcleaning	$11,102	$11,102	$1,219	$763	$788	NA	NA

Exhibit 7-2. Summary of Estimated Process-Dependent Cost Components for Selected Fabricare Technologies[a] (Cont'd)

Fabricare Technology[b]	Annual Cost Filters and Detergent[j]	Annual Cost Maintenance[k]	Total Annual Operating Cost[l]	Total Annual Cost[m]	Total Annual Cost/Pound
PCE	$1,913	$6,000	$14,077	$18,305	$0.34
HC	$1,551	$6,000	$19,607	$23,717	$0.44
Machine Wetcleaning	$3,162	$376	$5,089	$6,308	$0.12

NA means cost category not applicable for technology or that data are not available at this time.

[a] The values include the price of equipment and services directly related to the various drycleaning processes, but exclude costs for pressing, storefront operations, and rent. All values are in 1997 dollars and all calculations assume a 53,333-pound (24,191-kg) annual volume of clothes cleaned per facility.
[b] Configurations for fabricare technology include PCE dry-to-dry closed-loop with no carbon adsorber or with door fan and small carbon adsorber (PCE-C), as required by the PCE NESHAP regulation; HC transfer with recover dryer and condenser (HC-A2); and Unimac UW30 washer and DTB50 dryer.
[c] List price of 35 pound PCE drycleaning system includes control equipment, distillation unit, and filters; List price of 35- to 40-pound HC drycleaning system includes control equipment, filters, and an explosion kit.
[d] Base machine costs (actual or implied) are added to cost of control capital.
[e] Annual cost of drycleaning equipment, annualized using 7% interest and assuming equipment life of 15 years.
[f] PCE solvent cost based on $6.83 per gallon for PCE in 1997 dollars (BLS, 1997; USEPA, 1993) and "mileage" from EPA engineering estimates; HC solvent cost based on $2.24 per gallon for hydrocarbon solvent and "mileage" based on engineering estimates; wetcleaning solvents cost based on $3.06/100 feet^3 for water (BLS, 1997; USEPA, 1993).
[g] All technology energy costs are based (USEPA, 1991a) on $0.0764/kWh national average electricity cost (BLS, 1997).
[h] Regulatory compliance costs for PCE are based on 1.84% of total annual revenues of $200,000 (Gottlieb et al., 1997; NCAI, 1998).
[i] Hazardous waste disposal costs for PCE and HC based on $6.94 per gallon disposal cost (Beedle, 1998) and volume calculations from EPA engineering estimates, excluding disposal cost for potentially hazardous spotting chemicals. Hazardous waste associated with PCE-based machines includes filters, distillation residues, and spent carbon. Hazardous waste associated with HC-based machines includes spent cartridge filters and vacuum still bottoms.
[j] Cost includes of cleaning detergents, spotting chemicals, and replacement filters (Hill, Jr., 1994b; USEPA, 1993).
[k] Annual maintenance cost for PCE and HC based on 3.0% of total revenues of $200,000 annually; costs for machine wetcleaning based on 3.39% of total capital costs (Murphy, 1994).
[l] Includes solvent, energy, hazardous waste, filters, detergent, and maintenance costs. The cost of labor, another component of annual operating costs, is omitted due to lack of data.
[m] Includes all operating costs and annual capital costs.

7.2 ASSUMPTIONS AND COST ESTIMATION METHODOLOGY

Only those process-dependent cost components (i.e., equipment and chemicals) that are directly related to the various cleaning processes are included in these cost analyses. Operating costs that do not vary with the process used, such as storefront operations and rent, are excluded from these analyses. Note that rounding and unit conversions associated with cost components may result in slight differences between numbers reported in the text and the actual data.

Some of the costs are based on the average of prices offered by several vendors, while others are based on reported prices from a single vendor. Solvent and detergent cost estimates are adjusted to 1997 dollars using the Producer Price Index for Chemicals and Allied Products (PPI-Chem). All other cost estimates are adjusted to 1997 dollars using the Producer Price Index for Capital Equipment (PPI-CE) (BLS, 1997). Exhibit 7-3 shows the values from the PPI-CE and PPI-Chem indices. Cost figures are presented in constant 1997 dollars in order to allow direct comparison among the process options. A sample calculation of conversion to constant dollars based on PPI-CE is given below Exhibit 7-3.

Exhibit 7-3. Producer Price Index for Machines and Equipment (PPI-CE) and Chemicals and Allied Products (PPI-Chem)

Year	1982	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997[a]
PPI-CE	100	109.7	111.7	114.3	118.8	122.9	126.7	129.1	131.4	134.1	136.7	138.3	138.3
PPI-Chem	100	102.6	106.4	116.3	123.0	123.6	125.6	125.9	128.2	132.1	142.5	142.1	143.6

Source: BLS (1997)
[a] PPI-CE and PPI-Chem estimates based on 10-month average for 1997 (January to October).

Sample Calculation of Conversion to Constant Dollars - Data from Section 7.3.3:

Capital Cost for Retrofit of Equipment in 1994 dollars = $8,556
PPI-CE 1994 (base year) = 134.1
PPI-CE 1997 (current year) = 138.3

$$\$8{,}556 \text{ (1994 } \textit{dollars}\text{)} \times \left[\frac{138.3}{134.1}\right] = \$8{,}824 \text{ (1997 } \textit{dollars}\text{)}$$

7.2.1 Clothes Cleaning Plant Capacity

In this chapter, the model clothes cleaning plant for each technology is assumed to process an annual average clothing volume of 53,333 pounds.[1] This annual clothing volume for the average facility is derived by dividing the total volume of clothes cleaned using PCE and HC solvents in the commercial sector (1.92 billion pounds) by the number of firms using PCE and HC solvents in the commercial sector (36,000) (Wolf, 1998; Wong, 1998). Facilities are assumed to operate 312 days annually (6 days a week and 52 weeks a year [Shaffer, 1995]) and to have an average daily throughput of approximately 171 pounds of clothing.

[1]The total throughput of the model plant is 66,666 pounds, of which 80% is drycleaning or an alternative and 20% is washing (Faig, 1998). It is assumed that the revenue per pound is constant at $3, generating a revenue per facility of $200,000.

7.2.2 Equipment Capacity

The cost estimates for PCE assume a 35-pound (15.9 kg) nominal capacity machine with a distillation unit and filtration system, unless otherwise noted. This is the machine size most commonly used in the commercial sector (USEPA, 1991b). The price of retrofitting machines with emission control equipment is estimated for the same cleaning capacity. It is assumed that the PCE machines operate at 90% capacity (USEPA, 1993), and that 6 loads per day are needed to process the throughput.

The cost estimates for the HC machines assume a 40-pound (18.1 kg) nominal capacity machine that includes a washer/extractor (with filter and explosion kit) and a basic dryer. The HC solvent machines are assumed to operate at 80% capacity (Jenkins, 1994), resulting in a daily throughput of six loads per day.

The cost estimates for wetcleaning machines assume a 30-pound (13.6 kg) nominal capacity. Manufacturer estimates indicate that wetcleaning equipment is designed to be operated at 100% capacity, resulting in a daily throughput of six loads per day.

7.2.3 Capital Equipment Costs

Capital costs for equipment and the costs of retrofitting machines with control technologies are converted to annual cost equivalents using a 7% real cost of capital and a 15-year lifespan[2] (equivalent to using a capital recovery factor of 0.1098), to be consistent with previous clothes cleaning analyses (USEPA, 1993).[3] The example below demonstrates the annualization of capital costs and the calculation of capital equipment costs using constant dollars.

Sample Annualization Cost Calculation[4] - Data from Section 7.3.3:

Where:
A_c = Annualized cost
T_c = Total cost
i = Interest rate (7%)
n = Number of years (15)
[ ] = Note that bracketed term is the capital recovery factor of 0.1098

$$A_c = T_c \times \left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$
$$A_c = T_c \times 0.1098$$
$$A_c = \$27{,}801 \times 0.1098$$
$$A_c = \$3{,}053$$

[2]According to Ken Faig of the International Fabricare Institute (1996) the average life of wetcleaning washers and dryers is 15 to 18 years, comparable to that of drycleaning equipment. Fifteen years was assumed, to be consistent with prior analyses.

[3]The cost of capital used to analyze public investments and private investments is different. The real cost of capital of 7% is a typical value used in evaluating public investments. For the private firm deciding to purchase equipment, the appropriate value is the interest rate charged on the loan modified by the inflation over the course of the payments. The authors investigated the typical loans for clothes cleaning equipment and discovered that they varied considerably. In addition, the tax savings from depreciation must be included for an individual making a financial decision. The public financing rate has been used in this analysis.

[4]The annualization of capital equipment expenses allows recovery of the original investment over the course of the lifetime of the equipment (15 years in this case), accounting for the time value of currency. The discounted annualized costs (where the discount rate equals the interest rate) summed over the lifetime of the equipment is equal to the total immediate cost of purchasing the equipment (Perry and Chilton, 1973).

7.2.4 Equipment Maintenance Costs

The Neighborhood Cleaners Association International (NCAI) estimates the annual maintenance costs for PCE-based fabricare operations to be between 1.25% and 3% of total annual revenues, based on a range of standard garment pricing[5] (NCAI, 1998). The International Fabricare Institute (IFI) estimates annual equipment maintenance costs for PCE-based operations to be 2.27% to 3.26% of total annual revenue, based on an annual sales volume of $100,000 to $300,000 (IFI, 1992). The Pollution Prevention Environmental Research Center (University of California at Los Angeles/Occidental College) study averages the low-end IFI and NCAI estimates (2.27% and 1.25%, respectively) and applies a 50% preventive maintenance factor to yield 1.765% of total sales revenue. For the purpose of the CTSA, PCE and HC annual equipment maintenance costs are calculated as 3% of total annual revenues. The equipment maintenance costs for other technologies are noted directly in the corresponding text of this chapter.

7.2.5 Energy Costs

Energy costs are based on the national average commercial electricity price of $0.0764 per kilowatt-hour (EIA, 1997). Energy use estimates for each technology include only actual cleaning and drying equipment and do not include non-cleaning processes such as pressing. In cases where data are available, energy costs are provided for machines and emissions control technologies, based on estimates by equipment manufacturers and suppliers. Estimates for energy use of PCE emissions control technologies are derived from information in the PCE National Emission Standard for Hazardous Air Pollutants (NESHAP) (USEPA, 1991a). More recent energy use data for PCE transfer machines are not available because these machines are not currently in production.

Sample Calculation for Energy Consumption Costs - Data from Section 7.3.4:

Assumption: Energy use estimate of 725 kilowatt-hours/year is based on capacity of 105,240 pounds of clothes cleaned per year (USEPA, 1993).

53,333 pounds per year/105,240 pounds per year = 0.507 (adjustment for facility capacity)
Cost of Energy = $0.0764/kilowatt-hour x 725 kilowatt-hour/year x 0.507
Cost of Energy = $28/year

7.2.6 Installation Costs

Installation costs are included in the cost of retrofitting machines with emissions control technologies, as these costs are a necessary and unavoidable part of the retrofitting process. For the purpose of this analysis, installation costs are not included for new equipment because the installation costs of a new machine vary significantly. Replacing an existing machine requires relatively little installation cost, while an entirely new installation requires significantly higher costs to provide water, steam, and electricity supplies.

[5]The NCAI estimate of annual maintenance costs is based on a survey of 854 fabricare stores with between $130,000 and $334,000 in annual sales revenue (NCAI, 1998).

7.2.7 Solvent and Other Material Costs

Solvent costs may vary based on per-gallon and bulk prices.[6] PCE solvent costs range from $5.50/gallon to $8.01/gallon, based on estimates provided by manufacturers and distributors. A median PCE solvent price of $6.83/gallon is used for the purposes of this analysis.

HC solvent costs range as follows: (1) Stoddard solvent costs $1.50/gallon to $4.00/gallon, with a median price of $2.24/gallon; (2) DF-2000 costs $3.49/gallon to $5.01/gallon, for a median price of $3.79/gallon; and (3) Drylene solvent costs $7.50/gallon. For the purpose of this analysis, the median price of Stoddard solvent ($2.24/gallon) will be used to calculate total HC solvent costs, although it should be recognized that costs will vary depending upon which HC solvent is used.

Water for wetcleaning costs $2.73/100 cubic feet in 1993 dollars or $3.06/100 cubic feet in 1997 dollars (USEPA, 1993; BLS, 1997). This price includes the average cost of water and sewerage fees.

Sample Calculation for Solvent/Material Consumption Costs - Data from Section 7.3.3:

Assumed usage = 417 gallons PCE/year
Total Solvent Cost = 417 gallons PCE/year x $6.83/gallon PCE (1997 dollars)
= $2,848/year

7.2.8 Filters/Cleaning Supplies

PCE filters are estimated to cost $606 annually, and detergents and spotting chemicals for PCE machine configurations are calculated to cost $1,307 annually, for a total of $1,913 (BLS, 1997; USEPA, 1993). For the HC configurations, the filters cost $244 annually, while the detergents and spotting agent costs are estimated at $1,307 annually, for a total of $1,551 (BLS, 1997; Hill, Jr., 1994a). Annual costs for machine wetcleaning detergent, fabric softener, and spotting chemicals are calculated to be $2,877, $40, and $245, respectively, for a total of $3,162 (BLS, 1997).

7.2.9 Hazardous Waste Disposal Costs

Because PCE is a hazardous waste, the CTSA compares the costs of hazardous waste disposed. For the purposes of this analysis, all hazardous waste cost estimates provided in this chapter include only the cost of disposal and do not include the cost of associated paperwork and other regulatory compliance activities noted in Exhibit 7-2. The cost of disposing of potentially hazardous spotting chemicals is not included in this analysis. Hazardous waste disposal costs for PCE and HC-based equipment are calculated using a cost of $6.94 per gallon[7] and engineering estimates of volume. Hazardous waste cost estimates included in the HC estimates assume that all the waste products require hazardous waste disposal procedures. Wastes derived from HC drycleaning processes are not necessarily classified as hazardous wastes under environmental regulations. Wastes composed solely of HC products, such as well-drained filter cartridges and drained filter muck, are not likely to meet the criteria for classification as ignitable solids (USEPA, 1990). However, other cleaning process by-products (such as dissolved fats, dyes, and

[6]Several states have instituted annual usage fees ($100 to $2,500) and/or per-gallon taxes on PCE solvent, which can increase the purchase price of this product from $3.75 to $10.00 per gallon. Additional information regarding solvent use taxes is presented in Chapter 8 of this document.

[7]Hazardous waste costs are estimated at $111/16 gallons ($6.94/gallon) (Beedle, 1998).

cleaning products), in combination with the HC solvent, may create wastes that fail the Toxicity Characteristic Leaching Procedure (TCLP) and qualify as hazardous waste under the Resource Conservation and Recovery Act (RCRA) definition. Water is not a hazardous waste under environmental regulations. However, as with HC cleaning, wastes derived from using these solvents in clothes cleaning applications could generate some hazardous waste.

Sample Calculation for Annual Hazardous Waste Disposal Costs - Data from Section 7.3.2:

Assumed production of hazardous waste = 658 gallons/year
Hazardous Waste Disposal Cost = 658 gallons of hazardous waste/year x $6.94/gallon
= $4,567/year

7.2.10 Regulatory Compliance

Compliance with government regulations imposes industry-specific costs upon the private sector. Exhibit 7-1 lists many of the regulatory compliance cost categories pertinent to the fabricare industry, including expenditures for waste management. The range of equipment ages and types currently in use will result in variations in regulatory compliance costs within and across process categories. In addition, regulatory compliance costs will vary regionally due to differing local and state fees, taxes, and permitting procedures.[8] For the purpose of this analysis, the use of spotting agents is not factored into the regulatory cost estimates provided in this chapter.[9]

NCAI estimates that regulatory compliance costs associated with PCE technology are between 2.25% and 4.5% of total revenues[10] (NCAI, 1998). These costs include registration and permit fees for pollution abatement; hazardous waste disposal charges; USEPA and Occupational Safety and Health Administration (OSHA) compliance; local water pollution discharge fees; and other local, state, and federal fees. The Pollution Prevention Environmental Research Center (University of California at Los Angeles/Occidental College) study calculates regulatory compliance costs for drycleaning based on the NCAI estimate of 2.25% of annual revenue ($5,483) but subtracts out hazardous waste disposal costs ($1,010) and the cost of regulatory fees[11] ($851), for a final annual estimate of $3,622. Because hazardous waste costs have already been considered separately, regulatory compliance costs associated with PCE-

[8]Regulatory fees tend to vary, based on local and state requirements (Gottlieb et al., 1997).

[9]Spotting agents that contain regulated chemical ingredients are used by fabricare operators, regardless of the cleaning technology they employ. It is important for a user to consider the additional regulatory impact, and therefore additional cost, these chemicals might have upon a fabricare business.

[10]The NCAI estimates for regulatory compliance costs are based on a survey of 854 stores with annual sales revenue ranging from $130,000 to $364,000. The base price of cleaning a two piece suit ranges from $6.50 (4.5% estimate) to $8.50 (2.25% estimate) (NCAI, 1998).

[11]The PPERC/UCLA study includes the following annual regulatory fees in their cost of compliance for PCE drycleaning: hazardous waste control license ($412) and hazardous materials control license ($110) from the Los Angeles County Fire Department, South Cost Air Quality Management District annual operating fee ($168) and emissions fee (exempt; $0.21/pound of PCE emitted for businesses that emit more than 4,000 pounds annually), Los Angeles County Public Health licence fee ($111), and California Air Resources Board employee training course taken every three years by employees ($150) (Gottlieb et al., 1997).

based drycleaning are estimated to be 1.84% of total annual revenues, the percentage resulting from the Pollution Prevention Environmental Research Center (University of California at Los Angeles/Occidental College) study when the hazardous waste costs are subtracted from the regulatory compliance costs (Gottlieb et al., 1997).

No data are currently available for estimating the regulatory compliance costs associated with HC drycleaning. USEPA is currently in the process of writing a NESHAP regulation for HC solvents used in the fabricare industry. The proposed NESHAP is expected to be released by November 15, 1999, and then formally promulgated by November 15, 2000. Currently, HC drycleaners are regulated under the Clean Air Act by New Source Performance Standards, which include required record keeping, leak detection, and maintenance procedures. The NESHAP is expected to require HC solvent drycleaners to use maximum available control technology to reduce emissions from their fabricare operations (KSBEAP, 1997; Szykman, 1998). Therefore, this NESHAP could result in an increase in regulatory costs associated with Clean Air Act compliance over current levels. At this time, there are insufficient data to determine regulatory compliance costs for HC-based drycleaning operations. For the purpose of this analysis, regulatory compliance costs are excluded from the total cost calculation of this technology.

No data are currently available for estimating the regulatory compliance costs associated with wetcleaning. However, fabricare operators may be subject to permitting fees and record keeping costs associated with their local sewerage authority. At this time, there are insufficient data to determine total regulatory compliance costs for wetcleaning operations. For the purpose of this analysis, regulatory compliance costs are excluded from the total cost calculation of this technology.

7.2.11 Labor Costs

Labor costs associated with professional clothes cleaning operations vary based on the mix of employee job functions, qualifications and experience of workers, productivity of workers, equipment type and configuration, facility size, and geographic location of the facility. For example, rough pressers tend to earn a lower wage than specialized pressers, who are trained to work on intricate garments such as wedding dresses and expensive fabrics such as silks (Seitz, 1996). It is also noted that one employee may perform several job functions within a fabricare shop, each of which requires different skill levels. For example, an employee may work at the drop-off counter during part of his shift, in addition to sorting and washing clothing in the back of the facility. Because of this variability and the lack of available quantitative data, the labor costs associated with fabricare operations are not included in this cost model.

7.3 COST ESTIMATES FOR PCE MACHINE CONFIGURATIONS

The cost components of the eight PCE drycleaning machine configurations are summarized in Exhibit 7-4. The discussion that follows explains the cost estimates of each technological configuration of PCE equipment.

7.3.1 PCE Transfer with No Carbon Adsorption or Refrigerated Condenser (PCE-A1)

Capital Cost: New transfer machines are no longer available, so historic data must be used. The estimate of the price of an uncontrolled transfer drycleaning machine is based on responses to the Clean Air Act Section 114 Questionnaires, which was a survey conducted for the Chemical and Petroleum Products

Division, Office of Pesticides and Toxic Substances (USEPA, 1988). The price of a 35-pound transfer machine was estimated at $15,895 (1987 dollars), or $19,680 in 1997 dollars (BLS, 1997).

Solvent Cost: Assuming a solvent use of 627 gallons/year (USEPA estimates) and a solvent price of $6.83 per gallon, the solvent cost is $4,282. The mileage is 85 pounds per gallon.

Energy Cost: Data are not available for this technology.

Regulatory Compliance Cost: Regulatory compliance costs are estimated at 1.84% of annual revenue ($200,000), for a total of $3,680.

Hazardous Waste Disposal Costs: The estimate of hazardous waste disposal cost is based on engineering estimates of 658 gallons of waste generated per year and a disposal cost of $6.94 per gallon (Beedle, 1998), for a total of $4,567.

Cost of Filters/Cleaning Supplies: Each 35-pound capacity machine needs 20.24 replacement standard carbon core filters at $17.57 per filter and 7.59 double all carbon filters at $29.03 per filter (USEPA, 1993), for an annual cost of $576, or $606 in 1997 dollars (BLS, 1997). All costs presented for filters and cleaning supplies are average costs. (Individuals will not buy 7.59 filters but are likely to buy packages of 8 or 10. This is also true of cleaning supplies.) The annual cost of detergents and spotting chemicals is estimated at $1,307/year (BLS, 1997; USEPA, 1993), for a total supplies cost of $1,913 per year. The annual cost of supplies without spotting chemicals is $1,527 (BLS, 1997; USEPA, 1993).

Maintenance Cost: Maintenance costs are based on 3.0% of annual revenue ($200,000), for a total of $6,000.

7.3.2 PCE Transfer with Carbon Adsorber (PCE-A2)

Capital Cost: Current price quotes are not available for this configuration. The price for a retrofit carbon adsorber (CA) unit is based on information from the 1991 NESHAP document (USEPA, 1991a). The estimated cost of retrofitting an uncontrolled transfer machine with a CA is $6,976 (1989 dollars), or $8,121 in 1997 dollars (BLS, 1997). An alternative source of price information (not used but included for comparison) is a report from the Division of Air, Office of Policy and Program Analysis, New York State Department of Environmental Conservation, *Regulating PCE Emissions from Dry Cleaning Machines: An Economic and Public Health Impact Analysis* (NYSDEC, 1993). It estimates that the addition of a total vapor containment system, including a CA, to an existing transfer machine would cost from $10,000 to $12,000 including installation (1991 dollars, or between $10,916 and $13,099 in 1997 dollars) (BLS, 1997). The implied cost of an uncontrolled transfer equipment combination ($19,680 from Option PCE-A1) is added to the retrofit cost of $8,121 to give a total effective capital cost of $27,801.

Solvent Cost: Assuming a solvent use of 469 gallons/year (USEPA estimates) and a solvent price of $6.83 per gallon, the solvent cost is $3,203 (USEPA, 1993). The mileage is 114 pounds per gallon.

Energy Cost: Data are not available at this time.

Regulatory Compliance Cost: Regulatory compliance costs are estimated at 1.84% of annual revenue ($200,000) for a total of $3,680.

Exhibit 7-4. Estimated Process-dependent Cost Components of Selected PCE Machine Configurations[a]

Machine Configuration[b]	Capital Cost of Base Equipment[c] (Implied Cost)	Capitol Cost of Retrofit Control Technology[d]	Capital Cost Total[e]	Annualized Cost of Equipment[f]	Annual Cost Solvent[g]	Annual Energy Cost[h]	Regulatory Compliance Costs[i]
Transfer							
Transfer with no CA or RC (PCE-A1)	$19,680	$0	$19,680	$2,161	$4,282	NA	$3,680
Transfer with CA (PCE-A2)	$19,680	$8,121	$27,801	$3,052	$3,203	NA	$3,680
Transfer with RC (PCE-A3)	$19,680	$8,823	$28,503	$3,129	$2,848	NA	$3,680
Dry-to-Dry							
Dry-to-dry with no CA or RC (PCE-B1)	$31,781	$0	$31,781	$3,489	$3,832	$78	$3,680
Dry-to-dry with CA (PCE-B2)	$31,781	$7,477	$39,258	$4,310	$2,425	$94	$3,680
Dry-to-dry converted to closed-loop (PCE-B3)	$31,781	$7,607	$39,388	$4,325	$2,069	$106	$3,680
Dry-to-dry closed-loop with no CA or with door fan and small CA (PCE-C)	$38,511	$0	$38,511	$4,228	$1,434	$136	$3,680
Dry-to-dry closed-loop with unvented integral secondary CA (PCE-D)	$47,475	$0	$47,475	$5,213	$1,216	$186	$3,680

See notes at end of table.

Exhibit 7-4. Estimated Process-Dependent Cost Components of Selected PCE Machine Configurations[a] (Cont'd)

Machine Configuration[b]	Annual Cost Hazardous Waste[j]	Annual Cost Filters and Detergent[k]	Annual Cost Maintenance[l]	Total Annual Operating Cost[m]	Total Annual Cost[n]	Total Annual Cost/pound
Transfer						
Transfer with no CA or RC (PCE-A1)	$4,567	$1,913	$6,000	$16,762	$18,923	$0.35
Transfer with CA (PCE-A2)	$4,629	$1,913	$6,000	$15,745	$18,797	$0.35
Transfer with RC (PCE-A3)	$4,567	$1,913	$6,000	$15,328	$18,457	$0.35
Dry-to-Dry						
Dry-to-dry with no CA or RC (PCE-B1)	$4,567	$1,913	$6,000	$16,390	$19,879	$0.37
Dry-to-dry with CA (PCE-B2)	$4,629	$1,913	$6,000	$15,061	$19,371	$0.36
Dry-to-dry converted to closed-loop (PCE-B3)	$4,567	$1,913	$6,000	$14,655	$18,980	$0.36
Dry-to-dry closed-loop with no CA or with door fan and small CA (PCE-C)	$4,594	$1,913	$6,000	$14,077	$18,305	$0.34
Dry-to-dry closed-loop with unvented integral secondary CA (PCE-D)	$4,594	$1,913	$6,000	$13,909	$19,122	$0.36

NA means Not Available.

[a] The values include the price of equipment, labor, and services directly related to the various drycleaning processes but exclude costs for pressing, storefront operations, and rent. All values are in 1997 dollars and all calculations assume a 53,333 pound (24,191 kilogram) annual volume of clothes cleaned per facility.

[b] CA - carbon adsorber; RC - refrigerated condenser

[c] Average of list prices of 35 pound drycleaning machine or system with control equipment as shown. Price includes distillation unit and filters where applicable. Base technology prices are shown for the relevant, less controlled drycleaning equipment system on which the retrofit control equipment is mounted.

[d] Average of list prices for retrofitting control technology.

[e] Base machine costs (actual or implied) are added to cost of control capital.

[f] Annual cost of drycleaning equipment, annualized using 7% interest and assuming equipment life of 15 years.

[g] Based on $6.83 per gallon for PCE in 1997 dollars (BLS, 1997; USEPA, 1993) and "mileage" from USEPA engineering estimates.

[h] Based on (USEPA, 1991a) and $0.0764/kWh national average electricity cost (BLS, 1997).

[l] Based on 1.84% of total annual revenues of $200,000 (Gottlieb, 1997; NCAI, 1998).

[j] Based on $6.94 per -gallon PCE hazardous waste disposal cost (Beedle, 1998) and volume calculations from USEPA engineering estimates, excluding disposal costs for potentially hazardous spotting chemicals. Hazardous waste associated with PCE-based machines includes filters, distillation residues, and spent carbon.

[k] Cost of drycleaning detergents, spotting chemicals, and replacement filters (USEPA, 1993).

[l] Based on 3.0% of total revenues of $200,000 annually.

[m] Includes solvent, energy, hazardous waste, filters, detergent, and maintenance costs. The cost of labor, another component of annual operating costs, is omitted due to lack of data.

[n] Includes all operating costs and annual capital costs.

Hazardous Waste Disposal Costs: Hazardous waste costs are based on engineering estimates of 667 gallons per year. Assuming a hazardous waste disposal cost of $6.94 per gallon (Beedle, 1998), the total cost is $4,629.

Cost of Filters/Cleaning Supplies: Each 35 -pound capacity machine needs 20.24 replacement standard carbon core filters at $17.57 per filter and 7.59 double all carbon filters at $29.03 per filter (USEPA, 1993), for an annual cost of $576, or $606 in 1997 dollars (BLS, 1997). All costs presented for filters and cleaning supplies are average costs. (Individuals will not buy 7.59 filters but are likely to buy packages of 8 or 10. This is also true of cleaning supplies.) The annual cost of detergents and spotting chemicals is estimated at $1,307/year (USEPA, 1993;BLS, 1997), for a total supplies cost of $1,913 per year. The annual cost of supplies without spotting chemicals is $1,527 (USEPA, 1993; BLS, 1997).

Maintenance Cost: Maintenance costs are based on 3.0% of annual revenue ($200,000), for a total of $6,000.

7.3.3 PCE Transfer with Refrigerated Condenser (PCE-A3)

Capital Cost: The cost shown is based on quotes from two vendors. Kleen Rite will retrofit a transfer machine with a refrigerated condenser (RC) for a list price of $8,611, which includes a $300 installation fee (Becknell, 1994). ArtiChill will retrofit a transfer machine with an RC for a list price of $8,500, which includes a $500 installation fee (Stork, 1994). Indexing the average price of $8,556 to 1997 dollars brings the total to $8,823 (BLS, 1997). An alternative source of price information (not used in the table, but included for comparison) is the Source Reduction Research Partnership (SRRP, 1992). The SRRP estimates that retrofitting an uncontrolled transfer machine with an RC costs $9,366 in 1997 dollars (BLS, 1997). To calculate the annualized cost of equipment on a comparable basis with new equipment, the implied cost of an uncontrolled transfer equipment combination ($19,680 from Option PCE-A1) is added to the retrofit cost of $8,823 to give a total effective capital cost of $28,503 (BLS, 1997).

Solvent Cost: Assuming a solvent use of 417 gallons/year (USEPA estimates) and a solvent price of $6.83 per gallon (USEPA, 1993;BLS, 1997), the solvent cost is $2,848. The mileage is 128 pounds per gallon.

Energy Cost: Data are not available at this time.

Regulatory Compliance Cost: Regulatory compliance costs are estimated at 1.84% of annual revenue ($200,000) for a total of $3,680.

Hazardous Waste Disposal Costs: Hazardous waste costs are based on engineering estimates of 658 gallons per year. Assuming a hazardous waste disposal cost of $6.94 per gallon (Beedle, 1998), the total cost is $4,567.

Cost of Filters/Cleaning Supplies: Each 35-pound capacity machine needs 20.24 replacement standard carbon core filters at $17.57 per filter and 7.59 double all carbon filters at $29.03 per filter (USEPA, 1993), for an annual cost of $576, or $606 in 1997 dollars (BLS, 1997). All costs presented for filters and cleaning supplies are average costs. (Individuals will not buy 7.59 filters but are likely to buy packages of 8 or 10. This is also true of cleaning supplies.) The annual cost of detergents and spotting chemicals is estimated at $1,307/year (USEPA, 1993;BLS, 1997), for a total supplies cost of $1,913 per year. The annual cost of supplies without spotting chemicals is $1,527 (USEPA, 1993;BLS, 1997).

Maintenance Cost: Maintenance costs are based on 3.0% of total revenue ($200,000) for a total of $6,000.

7.3.4 PCE Dry-to-Dry with No Carbon Adsorber or Refrigerated Condenser (PCE-B1)

Capital Cost: Uncontrolled dry-to-dry machines are no longer available, so historical information must be used. The price for an uncontrolled dry-to-dry machine is based on a 1989 price sheet from Marvel Manufacturing Company (Villareal, 1994). The 1989 list price with a filter and still was $27,300. Adjusting to 1997 dollars brings the price to $31,781 (BLS, 1997). An alternative source of price information (not used but included for comparison) is the Clean Air Act Section 114 Questionnaires, which was a survey conducted for the Chemical and Petroleum Products Division, Office of Air Quality, Planning, and Standards. The median reported price of a 35-pound dry-to-dry machine was $24,000 in 1987 dollars (USEPA, 1988). Adjusting to 1997 dollars brings the total to $29,715 (BLS, 1997).

Solvent Cost: Assuming a solvent use of 561 gallons/year (USEPA estimates) and a solvent price of $6.83 per gallon, the solvent cost is $3,832. The mileage is 95 pounds per gallon.

Energy Cost: A Model M-30 Böwe Permac dry-to-dry machine with no CA or RC draws approximately 1.1 kilowatt-hours (kWh) of electricity (Morgal, 1998). Six loads per day (30 minutes per load) are needed to process the annual throughput of 53,333 pounds. Therefore, at a cost of $0.0764/kWh, annual energy costs are calculated to be $78.

Regulatory Compliance Cost: Regulatory compliance costs are estimated at 1.84% of annual revenue ($200,000), for a total of $3,680.

Hazardous Waste Disposal Costs: Hazardous waste costs are based on engineering estimates of 658 gallons per year. Assuming a hazardous waste disposal cost of $6.94 per gallon (Beedle, 1998), the total cost is $4,567.

Cost of Filters/Cleaning Supplies: Each 35-pound capacity machine needs 20.24 replacement standard carbon core filters at $17.57 per filter and 7.59 double all carbon filters at $29.03 per filter (USEPA, 1993), for an annual cost of $606 (BLS, 1997). All costs presented for filters and cleaning supplies are average costs. (Individuals will not buy 7.59 filters but are likely to buy packages of 8 or 10. This is also true of cleaning supplies.) The annual cost of detergents and spotting chemicals is estimated at $1,307/year (BLS, 1997; USEPA, 1993), for a total supplies cost of $1,913 per year. The annual cost of supplies without spotting chemicals is $1,527 (BLS, 1997; USEPA, 1993).

Maintenance Cost: Maintenance costs are based on 3.0% of total revenue ($200,000), for a total of $6,000.

7.3.5 PCE Dry-to-Dry with Carbon Adsorber (PCE-B2)

Capital Cost: The cost is based on quotes from two vendors. District Cleaners Equipment retrofits a 35-pound capacity vented dry-to-dry machine to a closed-loop machine with a CA unit for $7,000 to $8,000 (the median price of $7,500 is used to calculate the average price) (Immanuel, 1994). Ilsa Multi-Solver produces a free-standing CA unit for dry-to-dry vented machines for $7,000 (including $500 installation) (Lage, 1994). The average price of these two units is $7,250. Indexing for inflation brings the total price to $7,477 (BLS, 1997). An alternative source of price information (not used but included for comparison) is the New York State Department of Environmental Conservation report previously cited (NYSDEC,

1993), which estimates that the addition of a CA to an existing dry-to-dry machine would cost $6,000 including installation (1991 dollars, equivalent to $6,549 in 1997 dollars) (BLS, 1997). The implied cost of an uncontrolled dry-to-dry machine ($31,781 from Option PCE-B1) is added to the retrofit cost of $7,477 to give a total effective capital cost of $39,258 in 1997 dollars (BLS, 1997).

Solvent Cost: Assuming a solvent use of 355 gallons/year (USEPA estimate) and a solvent price of $6.83 per gallon, the solvent cost is $2,425. The mileage is 150 pounds per gallon.

Energy Cost: A Model M-30 Böwe Permac dry-to-dry machine draws approximately 1.1 kWh of electricity (Morgal, 1998). Six loads per day (30 minutes per load) are needed to process the annual throughput of 53,333 pounds. The total energy use of a CA unit on a dry-to-dry machine is 344 kWh/year reported in USEPA (1991a) for an annual throughput of 87,524 pounds per year. In this analysis, the throughput is 60.9% (53,333 pounds/87,524 pounds) of that used in USEPA (1991a). The adjusted annual energy use for the CA unit is therefore 210 kWh/year. Therefore, at a cost of $0.0764/kWh, annual energy costs are calculated to be $94.

Regulatory Compliance Cost: Regulatory compliance costs are estimated at 1.84% of annual revenue ($200,000) for a total of $3,680.

Hazardous Waste Disposal Costs: Hazardous waste costs are based on engineering estimates of 667 gallons per year. Assuming a hazardous waste disposal cost of $6.94 per gallon (Beedle, 1998), the total cost is $4,629.

Cost of Filters/Cleaning Supplies: Each 35-pound capacity machine needs 20.24 replacement standard carbon core filters at $17.57 per filter and 7.59 double all carbon filters at $29.03 per filter (USEPA, 1993), for an annual cost of $606 (BLS, 1997). All costs presented for filters and cleaning supplies are average costs. (Individuals will not buy 7.59 filters but are likely to buy packages of 8 or 10. This is also true of cleaning supplies.) The annual cost of detergents and spotting chemicals is estimated at $1,307/year (BLS, 1997; USEPA, 1993), for a total supplies cost of $1,913 per year. The annual cost of supplies without spotting chemicals is $1,527 (BLS, 1997; USEPA, 1993).

Maintenance Cost: Maintenance costs are based on 3.0% of total revenue ($200,000), for a total of $6,000.

7.3.6 PCE Dry-to-Dry Converted to Closed-Loop (PCE-B3)

Capital Cost: The price to retrofit a vented dry-to-dry machine with an RC unit is based on a survey of equipment offered by four drycleaning manufacturers and distributors. Pros Equipment (Hope, 1994) retrofits a 35-pound vented dry-to-dry machine to a closed-loop machine with an RC unit using a water-cooled condensing unit for $6,000, and an RC unit using an air-cooled condensing unit for $5,400. Although the air cooled unit is less expensive, 80% of Pros' current customers select the water cooled system because it tends to be both easier for them to understand and easier to install. Therefore, the $6,000 price is used to calculate the average. District Cleaners Equipment retrofits a 35-pound vented dry-to-dry machine to a closed-loop machine with an RC unit for $6,000 to $8,000 (the $7,000 midpoint is used to calculate the average) (Immanuel, 1994). ArtiChill sells the Arctic Dry 75, a closed-loop conversion system that retrofits a 35-pound capacity vented dry-to-dry machine to a closed-loop machine with an RC unit for $9,995 (Stork, 1994). The Vapor Condensing System by Kleen-Rite, a closed-loop conversion system that retrofits a 35-pound capacity vented dry-to-dry machine to a closed-loop machine with an RC unit, costs $6,507 (including $300 installation) (Becknell, 1994). The average price of these

four units is $7,376 (1994 dollars). Indexing to 1997 dollars brings the average price to $7,607 (BLS, 1997). In order to calculate the annualized cost of equipment on a comparable basis with new equipment, the implied cost of an uncontrolled dry-to-dry machine ($31,781 from Option PCE-2A) is added to the retrofit cost of $7,607 to give a total effective capital cost of $39,388 (BLS, 1997).

Solvent Cost: Assuming a solvent use of 303 gallons/year (USEPA estimates) and a solvent price of $6.83 per gallon, the solvent cost is $2,069. The mileage is 176 pounds per gallon.

Energy Cost: A Model M-30 Böwe Permac dry-to-dry machine draws approximately 1.1 kWh of electricity (Morgal, 1998). Six loads per day (30 minutes per load) are needed to process the annual throughput of 53,333 pounds. The total energy use of an RC unit on a dry-to-dry machine is 604 kWh/year, for an annual throughput of 87,524 pounds per year (USEPA, 1991a). In this analysis the throughput is 60.9% (53,333 pounds/87,524 pounds) of that used in USEPA (1991a). The adjusted energy use for the RC unit is therefore 368 kWh/year. Using the price of $0.0764/kWh, the total annual energy cost is calculated to be $106.

Regulatory Compliance Cost: Regulatory compliance costs are estimated at 1.84% of annual revenue ($200,000) for a total of $3,680.

Hazardous Waste Disposal Costs: Hazardous waste costs are based on engineering estimates of 658 gallons per year. Assuming a hazardous waste disposal cost of $6.94 per gallon (Beedle, 1998), the total cost is $4,567.

Cost of Filters/Cleaning Supplies: Each 35-pound capacity machine needs 20.24 replacement standard carbon core filters at $17.57 per filter and 7.59 double all carbon filters at $29.03 per filter (USEPA, 1993), for an annual cost of $606 (BLS, 1997). All costs presented for filters and cleaning supplies are average costs. (Individuals will not buy 7.59 filters but are likely to buy packages of 8 or 10. This is also true of cleaning supplies.) The annual cost of detergents and spotting chemicals is estimated at $1,307/year (BLS, 1997; USEPA, 1993), for a total supplies cost of $1,913 per year. The annual cost of supplies without spotting chemicals is $1,527 (BLS, 1997; USEPA, 1993).

Maintenance Cost: Maintenance costs are based on 3.0% of total revenue ($200,000), for a total of $6,000.

7.3.7 PCE Dry-to-Dry Closed-Loop with no Carbon Adsorber or with Door Fan and Small Carbon Adsorber (PCE-C)

Capital Cost: The price of a closed-loop dry-to-dry machine with an RC unit is based on a survey of equipment offered by six major drycleaning manufacturers. The six machines are Fibrimatic's Ecodry, with a purchase price of $24,500 (Du Bach, 1994); Fluormatic's Blue Tiger Model 37, with a list price of $39,500 (Moser, 1994); Marvel's Ranger 35, with a list price of $36,875 (Villareal, 1994); VIC's Model 1235FS, with a list price of $41,400 (Giesen, 1994); Boewe Passat's Model P535 (36-pound capacity), with a list price of $47,105 (Cannon, 1994); and Multimatic Shop Star 300, with an estimated list price of $34,667 (list price estimated based on purchase price of $26,000) (Immanuel, 1994). The average price of these six machines is $37,341. Indexing to 1997 dollars brings the total average price to $38,511 (BLS, 1997).

Solvent Cost: Assuming a solvent use of 210 gallons/year (USEPA estimates) and a solvent price of $6.83 per gallon, the solvent cost is $1,434. The mileage is 254 pounds per gallon.

Energy Cost: Model P-536 Böwe Permac dry-to-dry machine draws approximately 1.9 kWh of electricity (Morgal, 1998). Six loads per day (30 minutes per load) are needed to process the annual throughput of 53,333 pounds. Therefore, at a cost of $0.0764/kWh, annual energy costs are calculated to be $136.

Regulatory Compliance Cost: Regulatory compliance costs are estimated at 1.84% of annual revenue ($200,000) for a total of $3,680.

Hazardous Waste Disposal Costs: Hazardous waste estimates are based on engineering estimates of 662 gallons per year. Assuming a hazardous waste disposal cost of $6.94 per gallon (Beedle, 1998), the total cost is $4,594.

Cost of Filters/Cleaning Supplies: Each 35-pound capacity machine needs 20.24 replacement standard carbon core filters at $17.57 per filter and 7.59 double all carbon filters at $29.03 per filter (USEPA, 1993), for an annual cost of $606 (BLS, 1997). All costs presented for filters and cleaning supplies are average costs. (Individuals will not buy 7.59 filters but are likely to buy packages of 8 or 10. This is also true of cleaning supplies.) The annual cost of detergents and spotting chemicals is estimated at $1,307/year (BLS, 1997; USEPA, 1993), for a total supplies cost of $1,913 per year. The annual cost of supplies without spotting chemicals is $1,527 (BLS, 1997; USEPA, 1993).

Maintenance Cost: Maintenance costs are based on 3.0% of total revenue ($200,000), for a total of $6,000.

7.3.8 PCE Dry-to-Dry Closed-Loop with Unvented Integral Secondary Carbon Adsorber (PCE-D)

Capital Cost: The price for new "fourth generation" drycleaning equipment includes filters and a distillation unit and is based on a survey of three distributors and manufacturers: Fibrimatic's Ecostar 4th Plus, with a list price of $29,995 (Du Bach, 1994); Fluormatic's Blue Tiger 37 Next Generation, with a list price of $45,000 (Moser, 1994); and Boewe Passat's Model P535 (36-pound capacity), with a list price of $63,105 (Cannon, 1994). The average price for these three machines is $46,033. Indexing to 1997 dollars brings the average total price to $47,475 (BLS, 1997).

Solvent Cost: Assuming a solvent use of 178 gallons/year (USEPA estimates) and a solvent price of $6.83 per gallon, the solvent cost is $1,216. The mileage is 300 pounds per gallon.

Energy Cost: P-536 Böwe Permac dry-to-dry machine with CA unit (consorber) draws approximately 2.6 kWh of electricity (Morgal, 1998). Six loads per day (30 minutes per load) are needed to process the annual throughput of 53,333 pounds. Therefore, at a cost of $0.0764/kWh, annual energy costs are calculated to be $186.

Regulatory Compliance Cost: Regulatory compliance costs are estimated at 1.84% of annual revenue ($200,000) for a total of $3,680.

Hazardous Waste Disposal Costs: Hazardous waste estimates are based on engineering estimates of 662 gallons per year. Assuming a hazardous waste disposal cost of $6.94 per gallon (Beedle, 1998), the total cost is $4,594.

Cost of Filters/Cleaning Supplies: Each 35-pound capacity machine needs 20.24 replacement standard carbon core filters at $17.57 per filter and 7.59 double all carbon filters at $29.03 per filter (USEPA,

1993), for an annual cost of $606 (BLS, 1997). All costs presented for filters and cleaning supplies are average costs. (Individuals will not buy 7.59 filters but are likely to buy packages of 8 or 10. This is also true of cleaning supplies.) The annual cost of detergents and spotting chemicals is estimated at $1,307/year (BLS, 1997; USEPA, 1993) for a total supplies cost of $1,913 per year. The annual cost of supplies without spotting chemicals is $1,527 (BLS, 1997; USEPA, 1993).

Maintenance Cost: Maintenance costs are based on 3.0% of total revenue ($200,000), for a total of $6,000.

7.4 COST ESTIMATES FOR HYDROCARBON SOLVENT MACHINE CONFIGURATIONS

Exhibit 7-5 summarizes the three HC solvent machine configurations analyzed. The discussion that follows details the cost estimates of each technology configuration for HC solvents.

7.4.1 HC Transfer Machine with Standard Dryer and No Condenser (HC-A1)

Capital Cost: A transfer machine has two components, a washer/extractor machine and a dryer (or reclaimer). The solvent removed during the extractor process (i.e., spin drying) in the washer/extractor equipment is captured, filtered, and reused. The two components are available for sale separately. The price of an uncontrolled HC solvent transfer machine is based on a J&T Model 40 (40-pound capacity) washer/extractor (with filter and explosion kit), which sells for $23,900 (Jenkins, 1994) plus the average cost of a basic Cissell Dryer, $3,085 (Stanley, 1994). The combined price for the two components is $26,985 (1994 dollars). Indexing to 1997 dollars brings the total to $27,830 (BLS, 1997).

Solvent Cost: Assuming a solvent use of 2,159 gallons/year (USEPA estimates) and a Stoddard solvent price of $2.24 per gallon, the solvent cost is $4,836. The solvent mileage is 25 pounds per gallon.

Energy Cost: Data are not available at this time.

Regulatory Compliance Cost: Regulatory compliance costs are excluded from this analysis due to a lack of information.

Hazardous Waste Disposal Costs: Hazardous waste estimates are based on engineering estimates of 1,415 gallons per year. Assuming a hazardous waste disposal cost of $6.94 per gallon (Beedle, 1998), the total cost is $9,820. Note that HC solvent waste may not be considered hazardous waste under RCRA if their flashpoint is greater than 140°F. This is the case for DF-2000. Therefore, this value represents an upper bound estimate. If wastes are considered non-hazardous, operating expenses may be significantly reduced.

Cost of Filters/Cleaning Supplies: Each machine needs 4.92 replacement standard carbon core filters at $34 per filter and 1.64 double all carbon filters at $42 per filter (Hill, 1994a), for an annual cost of $244 in 1997 dollars (BLS, 1997). Adding the cost of detergents and spotting chemicals, $1,307 (BLS, 1997; USEPA, 1993), yields a total of $1,551 (BLS, 1997). The annual cost of supplies without spotting chemicals is $1,169 (BLS, 1997).

Maintenance Cost: Maintenance costs are based on 3.0% of total revenue ($200,000), for a total of $6,000.

Exhibit 7-5. Estimated Process-dependent Cost Components of Selected HC Solvent Machine Configurations[a]

HC Machine Configuration[b]	Capital Cost of Base Equipment[c] (Implied Cost)	Capital Cost of Retrofit Control Technology[d]	Capital Cost Total[e]	Annualized Cost of Equipment[f]	Annual Cost Solvent[g]	Annual Energy Cost[h]	Annual Cost Hazardous Waste[i]
Transfer - standard dryer (HC-A1)	$27,830	$0	$27,830	$3,056	$4,836	NA	$9,820
Transfer - recovery dryer with RC (HC-A2)	$37,432	$0	$37,432	$4,110	$2,236	NA	$9,820
Dry-to-dry closed-loop with RC (HC-B)	$52,082	$0	$52,082	$5,718	$1,151	$149	$9,820

Exhibit 7-5. Estimated Process-dependent Cost Components of Selected HC Solvent Machine Configurations[a] (Cont'd)

	Annual Regulatory Compliance Cost	Annual Cost Filters and Detergent[j]	Annual Cost Maintenance[k]	Total Annual Operating Cost[l]	Total Annual Cost[m]	Total Annual Cost/pound
Transfer - standard dryer (HC-A1)	NA	$1,551	$6,000	$22,207	$25,263	$0.47
Transfer - recovery dryer with RC (HC-A2)	NA	$1,551	$6,000	$19,607	$23,717	$0.44
Dry-to-dry closed-loop with RC (HC-B)	NA	$1,551	$6,000	$18,671	$24,389	$0.46

NA means Not Available.

[a] The value includes the price of equipment, labor, and services directly related to the various drycleaning processes but excludes costs for expenses such as pressing, storefront operations, and rent. All values are reported in 1997 dollars and all calculations assume a 53,333-pound (24,191 kilogram) annual volume of clothes cleaned per facility.

[b] CA - carbon adsorber; RC - refrigerated condenser.

[c] The list price of a 35- to 40 -pound drycleaning machine (or system) with control equipment as shown. The price includes filters and an explosion kit where applicable.

[d] Average of list prices for retrofitting control technology.

[e] Base machine costs (actual or implied) are added to cost of control capital.

[f] Annual cost of drycleaning equipment, annualized using 7% interest and assuming equipment life of 15 years.

[g] Based on $2.24 per gallon for HC solvent and "mileage" based on engineering estimates.

[h] Based on $0.0764/kWh national average electricity cost (BLS, 1997). Energy costs estimated to be 10% higher than those for comparable PCE machines (Hill, 1994a). The authors used the energy costs for PCE-C ($136) to calculate this value for HC-B.

[i] Based on $6.94 per gallon hazardous waste disposal cost (Beedle, 1998) and volume calculations from USEPA engineering estimates, excluding disposal cost for potentially hazardous spotting chemicals. Hazardous waste associated with HC-based machines includes spent cartridge filters and vacuum still bottoms. Note that HC solvent wastes may not be considered hazardous waste under RCRA if its flashpoint is less than 140°F.

[j] Cost of drycleaning detergents, spotting chemicals, and replacement filters (USEPA, 1993; Hill, 1994b).

[k] Maintenance costs based on 3.0% of annual revenues of $200,000.

[l] Includes solvent, energy, hazardous waste, filters, detergent, and maintenance costs. The cost of labor, another component of annual operating costs, is omitted due to lack of data.

[m] The estimate includes all operating costs and annual capital costs.

7.4.2 HC Transfer Machine with Recovery Dryer (HC-A2)

Capital Cost: The price of a transfer machine system, including a reclaimer dryer, is the sum of the washer/extractor in the transfer system in Option HC-A1 ($23,900), plus the price of the Hoyt Petro-Miser solvent reclaimer ($12,395) (King, 1994), or $36,295. Indexing the cost from 1994 dollars to 1997 dollars brings the combined total to $37,432 (BLS, 1997).

Solvent Cost: Assuming a solvent use of 998 gallons per year (USEPA estimates) and a Stoddard solvent price of $2.24 per gallon, the solvent cost is $2,236. The mileage is 53 pounds per gallon. The manufacturer claims the Petro-Miser reclaims from 3.5 to 5 gallons of solvent for every 100 pounds of clothes washed.

Energy Cost: Data are not available at this time.

Regulatory Compliance Cost: Regulatory compliance costs are excluded from this analysis, due to a lack of information.

Hazardous Waste Disposal Costs: Hazardous waste estimates are based on engineering estimates of 1,415 gallons per year. Assuming a hazardous waste disposal cost of $6.94 per gallon (Beedle, 1998), the total cost is $9,820. Note that HC solvent waste may not be considered hazardous waste under RCRA if its flashpoint is greater than 140°F. Therefore, this value represents an upper bound estimate. If wastes are considered non-hazardous, operating expenses may be significantly reduced.

Cost of Filters/Cleaning Supplies: Each machine needs 4.92 replacement standard carbon core filters at $34 per filter and 1.64 double all carbon filters at $42 per filter (Hill, 1994a), for an annual cost of $244 in 1997 dollars (BLS, 1997). Adding the cost of detergents and spotting chemicals, $1,307 (BLS, 1997; USEPA, 1993), yields a total of $1,551 (BLS, 1997). The annual cost of supplies without spotting chemicals is $1,169 (BLS, 1997).

Maintenance Cost: Maintenance costs are based on 3.0% of total revenue ($200,000), for a total of $6,000.

7.4.3 HC Dry-to-Dry Closed-Loop with Refrigerated Condenser (HC-B)

Capital Cost: The price of an HC dry-to-dry closed-loop machine with filter and RC that uses an azeotropic process during the final aeration is based on the $50,500 price for a Midwest 35 pound capacity machine ($41,000 for machine, $5,000 for filter, and $4,500 for RC) (Hill, 1994b). Indexing the cost to 1997 dollars brings the total price to $52,082 (BLS, 1997). A distillation unit can be added for $10,000 but would not be necessary for good performance, according to the machine's supplier (Hill, 1994b).

Solvent Cost: Assuming a solvent use of 514 gallons per year (USEPA estimates) and a Stoddard solvent price of $2.24 per gallon, the solvent cost is $1,151. The solvent mileage is 104 pounds of clothes cleaned per gallon of solvent.

Energy Cost: Energy costs, based on Hill's assumption that HC process energy costs are 10% higher than those for a comparable PCE drycleaning machine (PCE-C), are estimated to be $149.

Regulatory Compliance Cost: Regulatory compliance costs are excluded from this analysis due to a lack of information.

Hazardous Waste Disposal Costs: Hazardous waste estimates are based on engineering estimates of 1,415 gallons per year. Assuming a hazardous waste disposal cost of $6.94 per gallon (Beedle, 1998), the total cost is $9,820. Note that HC solvent waste may not be considered hazardous waste under RCRA if its flashpoint is greater than 140°F. Therefore, this value represents an upper bound estimate. If wastes are considered non-hazardous, operating expenses may be significantly reduced.

Cost of Filters/Cleaning Supplies: Each machine needs 4.92 replacement standard carbon core filters at $34 per filter and 1.64 double all carbon filters at $42 per filter (Hill, 1994a) for an annual cost of $244 in 1997 dollars (BLS, 1997). Adding the cost of detergents and spotting chemicals, $1,307 (BLS, 1997; USEPA, 1993), yields a total of $1,551 (BLS, 1997). The annual cost of supplies without spotting chemicals is $1,169 (BLS, 1997).

Maintenance Cost: Maintenance costs are based on 3.0% of total revenue ($200,000), for a total of $6,000.

7.5 COST ESTIMATES FOR MACHINE WETCLEANING

Exhibit 7-6 details the cost components for machine wetcleaning. The discussion below provides information on the cost estimates of for this technology configuration. Capital costs include both washing and drying.

Capital Cost: Wetcleaning equipment ranges in price considerably based on the size and sophistication of the equipment. Six suppliers and their list prices are the Aqua Clean 80S ($36,380) and 80G ($33,475); the Böwe Permac Wash 200 with a 35-pound capacity including single reuse tank, circulation pump, and door pump with spray ($37,605); the Unimac UW30 with a 30-pound capacity ($8,373) and the DTB50 dryer with a 75-pound capacity ($2,729); the Marvel ADS 60# with a 60-pound capacity including thermometer, alarm, steam injection, extra supply, and two thermal fills ($25,585); the Milnor 30022 F8W with a 55-pound capacity ($17,245 without dryer; $25,061 with dryer); and the Daewoo DWF-1088PA with a 24-pound capacity ($1,099)[12] (Fleck, 1998; Schmelik, 1998; Star and Vasquez, 1997). The configuration of the Unimac UW30 washer and DTB50 dryer will be used in this analysis. The total capital cost for this equipment is $11,102. Based on Unimac specifications, this equipment is expected to run at 100% capacity, resulting in 6 loads per day for an annual throughput of 53,333 pounds of clothes (Fleck, 1998; Schmelik, 1998).

Solvent Cost: The solvent used in machine wetcleaning is water. Based on Unimac's specifications, an average of 3.5 gallons of water is used per pound of clothes cleaned. The price of water is $3.06/100 ft^3 (USEPA, 1993; BLS, 1997). Based on an annual throughput of 53,333 pounds, the total cost is $763 in 1997 dollars (BLS, 1997; Fleck, 1998; Schmelik, 1998).

[12]The large price difference between Daewoo brand wetcleaning machines and the other commercial brands is associated with the following factors: (1) Daewoo machines have pre-programmed cycles, while a fully programmable microprocessor control is available for many of the other brands; and (2) the capacity of the Daewoo machines is considerably less than many of the other manufacturer's models (Star, 1998).

Exhibit 7-6. Estimated Process-dependent Cost Components for Machine Wetcleaning[a]

Technology	Total Capital Cost of Equipment	Annualized Cost of Equipment[b]	Annual Cost Solvent[c]	Annual Energy Cost[d]	Annual Cost Hazardous Waste[e]	Annual Cost Filters and Supplies[f]
Machine Wetcleaning	$11,102	$1,219	$763	$788	NA	$3,162

Exhibit 7-6. Estimated Process-dependent Cost Components for Machine Wetcleaning[a] (Cont'd)

Technology	Annual Cost Regulatory Compliance[g]	Annual Cost Maintenance[h]	Total Annual Operating Cost[i]	Total Annual Cost[j]	Total Annual Cost/Pound
Machine Wetcleaning	NA	$376	$5,089	$6,308	$0.12

NA means data are unavailable at this time.
[a] The values include the price of equipment and services directly related to machine wetcleaning but exclude costs for pressing, storefront operations, and rent. All values are in 1997 dollars, and all calculations assume a 53,333 pound annual volume of clothes cleaned per facility.
[b] Annual cost of equipment, annualized using 7% interest; assuming equipment life of 15 years.
[c] Solvent costs based on $3.06/100 cubic feet for water (BLS, 1997; USEPA, 1993).
[d] Assumes $0.0764/kWh national average electricity cost (BLS, 1997).
[e] No hazardous waste disposal costs are estimated for machine wetcleaning. However, some spotting agents and wetcleaning detergents may contain chemical constituents that are considered RCRA hazardous wastes.
[f] Assumes detergent costs ($2,878), fabric softener costs ($40), and spotting chemical costs ($245).
[g] Regulatory costs could not be estimated at this time.
[h] Machine wetcleaning maintenance costs are based on 3.39% of total capital costs (Murphy, 1994).
[i] Includes solvent, energy, hazardous waste, filters, detergent, and maintenance costs. The cost of labor, another component of annual operating costs, is omitted due to lack of data.
[j] Includes all operating costs and annual capital costs.

Energy Cost: The total energy draw of the washer is 2.2 kWh with an average cycle time of 25 minutes. The dryer uses 9.18 kWh of energy with an average cycle time of 30 minutes. Using the price of $0.0764 per kWh, the total energy cost is calculated to be $788 (Fleck, 1998; Schmelik, 1998).

Hazardous Waste Disposal Cost: This analysis assumes that no hazardous waste disposal costs are associated with the wetcleaning process. However, some spotting agents (e.g., PCE and trichloroethylene) and wetcleaning detergents may contain chemical constituents that are considered RCRA hazardous wastes when they are present in a waste water stream.

Regulatory Compliance Cost: Machine wetcleaning technology is too new to the fabricare industry for regulatory compliance costs to be estimated at this time.

Cost of Filters/Cleaning Supplies: Unimac estimated detergent costs of $1.19 (1993 dollars) to clean 30-pounds of lightly soiled clothes and $1.72 (1993 dollars) to clean 30-pounds of heavily soiled clothes. An average price of $1.46 (1993 dollars) per 30-pounds of clothes cleaned is used, assuming that 50% of loads are lightly soiled and 50% are heavily soiled (BLS, 1997). Chemicals used include Seitz Chemicals Company's Frankolan S and Frankopal W. The ingredients of these detergents are proprietary information and therefore confidential. For an annual throughput of 53,333 pounds of clothes cleaned, detergent costs

are $2,877 in 1997 dollars (BLS, 1997). The total cost of $3,162 includes fabric softener ($40) and spotting chemicals ($245) in 1997 dollars (BLS, 1997).

Maintenance Cost: For the purpose of this analysis, the wetcleaning equipment maintenance cost is estimated as 2% per year of the purchase price with a major overhaul, costing 8% of the purchase price, every 5 years for the life of the machine (Murphy, 1994). These investments are annualized using 7% over the 15-year life span of the equipment, for an annual maintenance cost of 3.39% of the capital cost. The total annual maintenance cost is $376. This estimate is consistent with the UCLA/PPERC study wetcleaning maintenance estimate of $379 annually for 15 years, which includes replacing the door lock, water drain valve, water extractor bearings, circulation pumps, and computer control unit (Gottlieb et al., 1997).

REFERENCES

Becknell, C. 1994. Personal communications between Cary Becknell, Safety-Kleen, and Cassandra De Young, Abt Associates Inc. August 22 and September 1.

Beedle, L. 1998. Personal communication between Lee Beedle, Safety-Kleen of Grand Junction, CO, and Jonathan Greene, Abt Associates Inc. March 19.

BLS. 1997. Bureau of Labor Statistics. Downloaded from the BLS Information Bulletin Composite File of the Producer Price Index for Capital Equipment and Chemicals and Allied Products. U.S. Department of Labor, Bureau of Labor Statistics, Office of Prices and Consumer Living Conditions.

Cannon, B. 1994. Personal communications between Barry Cannon, Böwe Passat/Permac, and Cassandra De Young, Abt Associates Inc. August 11 and 16.

Du Bach, C. 1994. Personal communication between Chris Du Bach, Fibrimatic, and Cassandra De Young, Abt Associates Inc. August 17.

EIA. 1997. U.S. Department of Energy, Energy Information Administration. Monthly Energy Report Database. http://tonto.eia.doe.gov/mer/mer-toc-dt.cfm

Faig, K. 1996. Personal communication between Ken Faig, International Fabricare Institute, and Alice Tome, Abt Associates Inc.

Faig, K. 1998. Personal communication between Ken Faig, International Fabricare Institute, and Alice Tome, Abt Associates Inc. January.

Fleck, T. 1998. Personal communication between Tom Fleck, Raytheon Commercial Appliances, and Jonathan Greene, Abt Associates Inc. April 17.

Giesen, L. 1994. Personal communication between Leo Giesen, VIC Manufacturing, and Cassandra De Young, Abt Associates Inc. August 11.

Gottlieb, R., J. Goodheart, P. Sinsheimer, C. Tranby, and L. Bechtel. 1997. Pollution Prevention in the Garment Care Industry: Assessing the Viability of Professional Wet Cleaning. UCLA/Occidental College Pollution Prevention Education and Research Center. Los Angeles, CA. December.

Hill, J., Jr. 1994a. Personal communication between Jim Hill, Jr., Hill Equipment Company, and Leland Deck, Abt Associates Inc. March.

Hill, J., Jr. 1994b. Personal communications between Jim Hill, Jr., Hill Equipment Company, and Cassandra De Young, Abt Associates Inc. June and August.

Hope, B. 1994. Personal communications between Bruce Hope, Pros Equipment, and Cassandra De Young, Abt Associates Inc. July.

IFI. 1992. International Fabricare Institute. Results of IFI Survey of 1991 Operating Costs. September.

Immanuel, F., Jr. 1994. Personal communication between Frank Immanuel Jr., District Cleaners Equipment, and Cassandra De Young, Abt Associates Inc. August 11.

Jenkins, L. 1994. Personal communication between Lauri Jenkins, Four State Machinery, and Cassandra De Young, Abt Associates Inc. August 18.

King, P. 1994. Personal communication between Pat King, Hoyt Corporation, and Cassandra De Young, Abt Associates Inc. August 22.

KSBEAP. 1997. Kansas Small Business Environmental Assistance Program. Kansas Dry Cleaners: Complying with Kansas Environmental Regulations. The University of Kansas, Division of Continuing Education. Lawrence, KS. August.

Lage, A. 1994. Personal communications between Al Lage, Columbia-Ilsa, and Cassandra De Young, Abt Associates Inc. August 17 and 18.

Morgal, B. 1998. Personal communication between Bill Morgal, Böwe Permac, and Jonathan Greene, Abt Associates Inc. March 25.

Moser, J. 1994. Personal communication between Joe Moser, Fluormatic, and Cassandra De Young, Abt Associates Inc. August 22.

Murphy, M. 1994. Personal communication between Mike Murphy, Unimac, and Cassandra De Young, Abt Associates Inc. August 26.

NCAI. 1998. Neighborhood Cleaners Association International. NCAI Bulletin: Cost Comparison Chart for 1998. March.

NYSDEC. 1993. New York State Department of Environmental Conservation. Regulating PCE emissions from dry cleaning machines: an economic and public health impact analysis. Office of Policy and Program Analysis and Division of Air. Albany, NY. March.

Perry, R., and C. Chilton. 1973. Chemical Engineers Handbook, 5th edition. McGraw-Hill Inc.

Pindyck, R., and D. Rubeinfeld. 1989. Microeconomics. Macmillan Publishing Company. New York, NY.

Schmelik, T. 1998. Personal communication between Tom Schmelik, Raytheon Commercial Appliances, and Jonathan Greene, Abt Associates Inc. April 17.

Seitz, W. 1996. Personal communication between William Seitz, National Cleaners Association, and Jonathan Greene, Abt Associates Inc. December 19.

Shaffer, W. 1995. Letter to Joseph Breen, USEPA, from William B. Shaffer Jr. on behalf of the Martinizing Environmental Group. September 22.

SRRP. 1992. Source Reduction Research Partnership. Source reduction and recycling of halogenated solvents in the dry cleaning industry. Technical support document. Metropolitan Water District of Southern California and the Environmental Defense Fund. Pasadena, CA.

Stanley, M. 1994. Personal communication between Mary Stanley, Cissell Manufacturing, and Cassandra De Young, Abt Associates Inc. August 23.

Star, A. 1998. Personal communication between Anthony Star, Center for Neighborhood Technology, and Jonathan Greene, Abt Associates Inc. April 22.

Star, A., and C. Vasquez, 1997. Wet Cleaning Equipment Report: A Report on Washers, Dryers, Finishing Equipment, and Detergents for Machine-based Professional Wet Cleaning. The Center for Neighborhood Technology (CNT). May.

Stork, B. 1994. Personal communication between Bill Stork, ArtiChill, and Cassandra De Young, Abt Associates Inc. August 15.

Szykman, J. 1998. Personal communication between Jim Szykman, USEPA Office of Air Quality Planning and Standards, and Jonathan Greene, Abt Associates Inc. January 28.

USEPA. 1988. U.S. Environmental Protection Agency. Options for regulating PCE emissions in the dry cleaning industry: a cost-benefit analysis. Draft report. Office of Pesticides and Toxic Substances. Washington, DC.

USEPA. 1990. U.S. Environmental Protection Agency. Drycleaning and laundry plants, RCRA/ Superfund fact sheet. EPA/530-SW-90-027b. Draft environmental impact statement. EPA-450/3-91-020a. Office of Air Quality, Planning and Standards. Washington, DC.

USEPA. 1991a. U.S. Environmental Protection Agency. Dry cleaning facilities - background information for proposed facilities. Draft environmental impact statement. EPA-450/3-91-020a. Office of Air Quality, Planning and Standards. Washington, DC. November.

USEPA. 1991b. U.S. Environmental Protection Agency. Economic Impact Analysis of regulatory controls in the dry cleaning industry. Final. EPA-450/3-91-021. Office of Air Quality, Planning and Standards. Washington, DC. October.

USEPA. 1993. U.S. Environmental Protection Agency. Multiprocess wet cleaning cost and performance comparison of conventional dry cleaning and an alternative process. EPA 744-R-93-004. Office of Pollution Prevention and Toxics. Washington, DC.

USEPA. 1997. U.S. Environmental Protection Agency. Comment document of the cleaner technologies substitutes assessment for the fabricare industry project. Attachment to comment #6-6. Material adapted from information provided to commenter by Tellus Institute.

Villareal, J. 1994. Personal communications between Joe Villareal, Marvel, and Cassandra De Young, Abt Associates Inc. August 11 and 22.

Wolf, K. 1998. Personal communication between Kathleen Wolf, Institute for Research and Technical Assistance, and Alice Tome, Abt Associates, Inc. January.

Wong, T. 1998. Personal communication between Todd Wong, California Air Resources Board, and Alice Tome, Abt Associates Inc. January.